# MAAD-000523

## Digital Attenuator, 6-Bit, Serial / Parallel Control
## 31.5 dB, 0.7 - 6.0 GHz

Rev. V2

## Features

- Integrated CMOS/TTL Compatible Driver
- Parallel & Serial (P/S) Control with power-up state selection
- Insertion Loss: 1.6 dB typical @ 2.1 GHz
- IP3: 50 dBm typical @ 2 GHz
- Attenuation Accuracy:
      +/-(0.4 + 4% of attenuation setting) dB
- 0.5-dB Attenuation Steps to 31.5 dB
- Useable from 0.4 to 8.0 GHz
- Lead-Free 4 mm 24-Lead PQFN Package
- Halogen-Free "Green" Mold Compound
- RoHS* Compliant and 260°C Re-flow Compatible
- Small Relative Phase Variation per Bit

## Description

The MAAD-000523 is a 6-bit, 0.5-dB step GaAs MMIC digital attenuator in a lead-free 4 mm  24 lead PQFN surface mount plastic package. This device is ideally suited for use where high accuracy, very low power consumption and low intermodulation products are required. Typical applications include Cellular Basestation $R_X$/$T_X$ Line-up, Femtocells, and other gain / level control circuits.
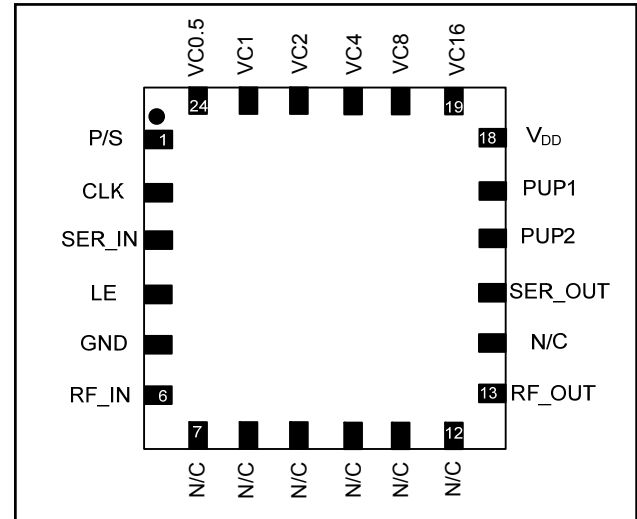
This attenuator is controlled with either a SPI compatible serial interface or a 6 bit parallel word.

## Functional Schematic [3,4]



3. Blocking capacitors are required on all RF ports.
4. For optimum RF performance all N/C's should be terminated to GND.

## Pin Configuration

| Pin No. | Function | Pin No. | Function |
|---|---|---|---|
| 1 | P/S | 13 | RF_OUT |
| 2 | CLK | 14 | No Connection |
| 3 | Serial IN | 15 | Serial OUT |
| 4 | LE | 16 | PUP2 |
| 5 | Ground | 17 | PUP1 |
| 6 | RF_IN | 18 | $V_{DD}$ |
| 7 | No Connection | 19 | VC16 |
| 8 | No Connection | 20 | VC8 |
| 9 | No Connection | 21 | VC4 |
| 10 | No Connection | 22 | VC2 |
| 11 | No Connection | 23 | VC1 |
| 12 | No Connection | 24 | VC0.5 |

## Ordering Information [1]

| Part Number | Package |
|---|---|
| MAAD-000523-TR1000 | 1000 piece reel |
| MAAD-000523-TR3000 | 3000 piece reel |
| MAAD-000523-001SMB | Sample Board |

1. Reference Application Note M513 for reel size information.
2. All sample boards include 5 loose parts.

* Restrictions on Hazardous Substances, European Union Directive 2002/95/EC.

- **North America** Tel: 800.366.2266 • **Europe** Tel: +353.21.244.6400
- **India** Tel: +91.80.43537383 • **China** Tel: +86.21.2407.1588
Visit www.macomtech.com for additional data sheets and product information.
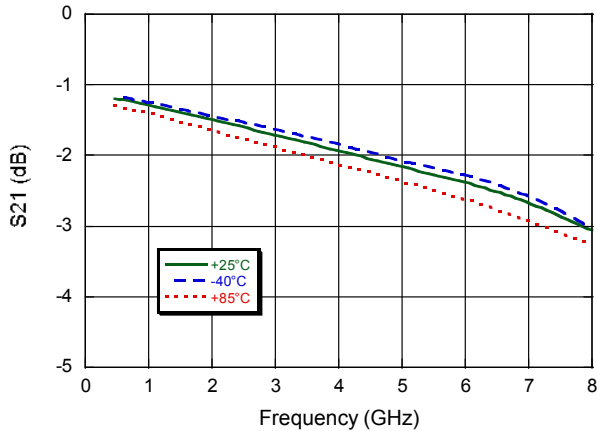
*M/A-COM Technology Solutions Inc. and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice.*

**m/A-COM**
Technology Solutions

## Digital Attenuator, 6-Bit, Serial / Parallel Control
## 31.5 dB, 0.7 - 6.0 GHz

Rev. V2

### Electrical Specifications [5]: $T_A = 25°C$, $Z_0 = 50\ \Omega$, $V_{DD} = 5\ V$, $V_C = 0/+5\ V$ [6]

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Reference Insertion Loss | 0.7 GHz<br>2.1 GHz<br>4.0 GHz<br>6.0 GHz | dB | —<br>—<br>—<br>— | 1.3<br>1.6<br>2.0<br>2.5 | —<br>2.3<br>—<br>— |
| Attenuation Accuracy | 0.7 - 6.0 GHz | ± (0.4 + 4% of attenuation setting) dB typ. | | | |
| VSWR | 0.7 - 6.0 GHz | Ratio | — | 1.2:1 | — |
| Trise, Tfall | 10% to 90% RF, 90% to 10% RF | ns | — | 70 | — |
| Ton, Toff | 50% Control to 90% RF,<br>50% Control to 10% RF | ns | — | 100 | — |
| Settling Time Loss Delta (Gate Lag) | RF Loss Difference within 30 µs to 500 µs @ 2 GHz and 500 µs Pulse | dB | — | 0.2 | — |
| Transients | In Band | mV | — | 50 | — |
| Input P1dB | 2.0 GHz | dBm | — | 25 | — |
| $IP_2$ | 2-Tone, +10 dBm/tone, 1 MHz Spacing 2.0 - 6.0 GHz | dBm | — | 75 | — |
| $IP_3$ | 2-Tone, +10 dBm/tone, 1 MHz Spacing 2.0 - 6.0 GHz | dBm | — | 50 | — |
| $I_{DD}$ | $V_{DD}$ = 5V | µA | 0 | — | 600 |

5. External DC blocking capacitors are required on all RF ports. Loss varies at 0.003 dB/°C.

### Truth Table [6]

| VC16 | VC8 | VC4 | VC2 | VC1 | VC0.5 | Attenuation (dB) |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | Reference IL |
| 1 | 1 | 1 | 1 | 1 | 0 | 0.5 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 | 1 | 2 |
| 1 | 1 | 0 | 1 | 1 | 1 | 4 |
| 1 | 0 | 1 | 1 | 1 | 1 | 8 |
| 0 | 1 | 1 | 1 | 1 | 1 | 16 |
| 0 | 0 | 0 | 0 | 0 | 0 | 31.5 |

6. 0 = 0 to 0.8V, 1 = 2 to 5V.

### Absolute Maximum Ratings [7,8]

| Parameter | Absolute Maximum |
|---|---|
| Input Power 700 - 6000 MHz | +27 dBm |
| Operating Voltage | 6 V |
| Control Voltage | -0.5 V $\leq V_C \leq$ 5.5 V |
| Operating Temperature | -40°C to +85°C |
| Junction Temperature | +150°C |
| Storage Temperature | -65°C to +150°C |

7. Exceeding any one or combination of these limits may cause permanent damage to this device.
8. M/A-COM Technology Solutions does not recommend sustained operation near these survivability limits.
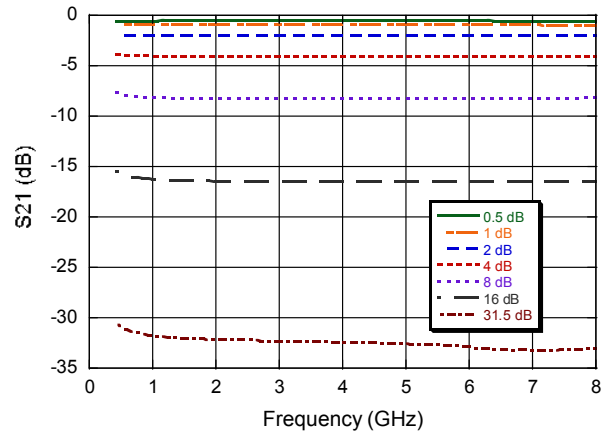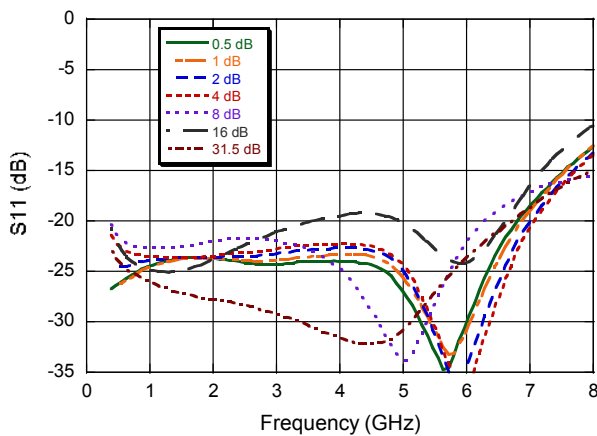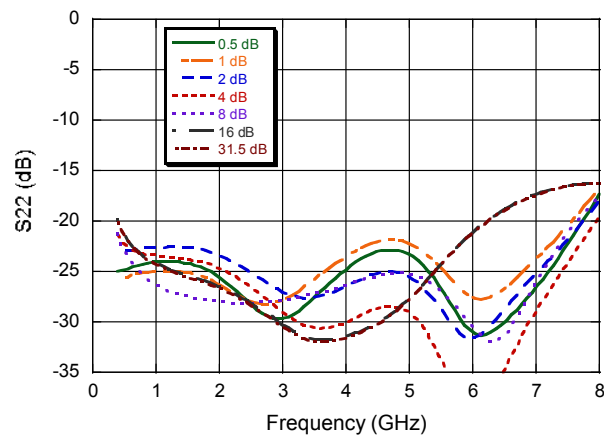
## Typical Performance Curves

*Insertion Loss*



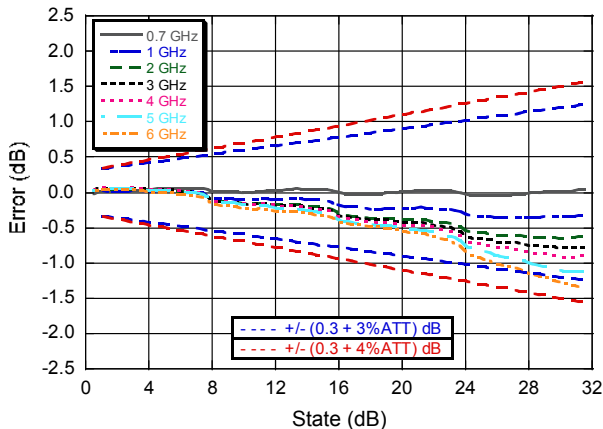*Relative Attenuation across all major states*
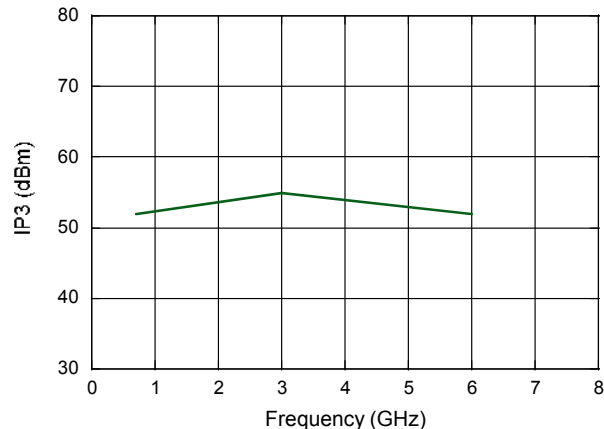


*Input Return Loss, across all attenuation states*



*Output Return Loss, across all attenuation states*



*Step Error vs. State over Frequency*



*IP3*



3

## Typical Performance Curve:

*Relative Phase Variation vs. Frequency and all states*
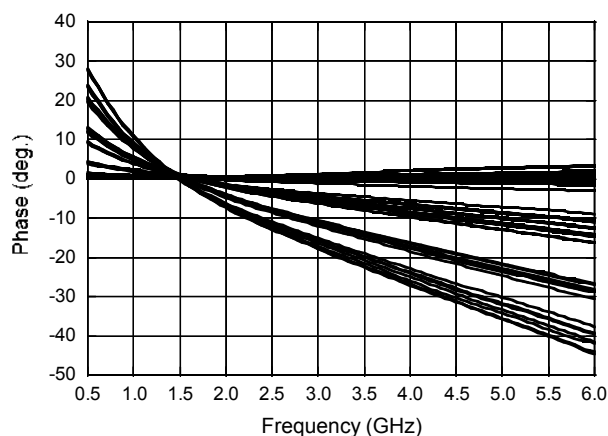


## Handling Procedures

Please observe the following precautions to avoid damage:

## Static Sensitivity

Gallium Arsenide Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

## *Lead Free 4* mm 24-Lead PQFN[†]



NOTES:
1. REFERENCE JEDEC M0-220, VAR VGGD-2 FOR ADDITIONAL DIMENSIONS AND TOLERANCE INFORMATION.
2. REFERENCE S2083 APPLICATION NOTE FOR PCB FOOTPRINT INFORMATION.
3. ALL DIMENSIONS SHOWN AS INCHES/MM.
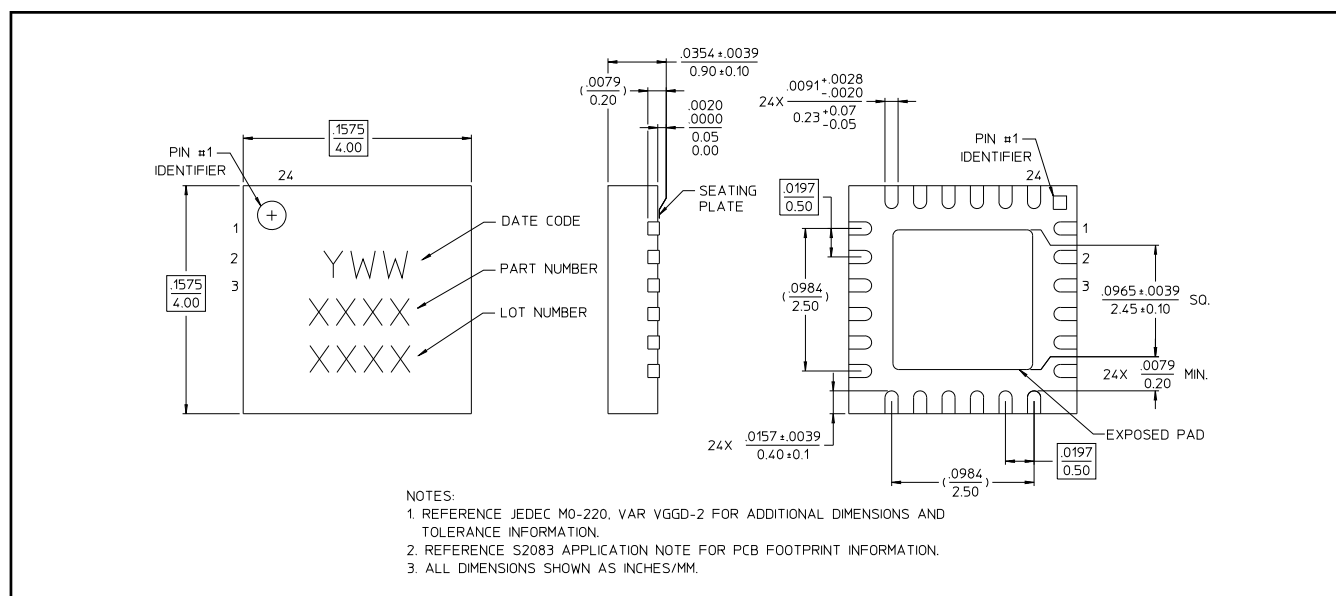
[†] Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 1 requirements.
Plating is 100% matte tin over copper.

## Functionality
### Modes of Operation: Serial, Direct Parallel, and Latched Parallel

### Mode Truth Table

| P/S | LE | Mode |
|-----|-----|------|
| 1 | X | Serial |
| 0 | Constant High | Direct Parallel |
| 0 | Pulsed | Latched Parallel |

### Serial Mode

The serial control interface (SERIN, CLK, LE, SEROUT) is compatible with the SPI protocol. SPI mode is activated when P/S is kept high. The 6-bit serial word must be loaded with the MSB first. After shifting in the 6 bit word, bringing LE high will set the attenuator to the desired state. While LE is high the CLK is masked to protect the data while implementing the change. SEROUT is the SERIN delayed by 6 clock cycles.

When P/S is low, the serial control interface is disabled and the serial input register is loaded asynchronously with parallel digital inputs.

For all modes of operations, the outputs will stay constant while LE is kept low.

### Direct Parallel Mode

The parallel mode is enabled when P/S is set to low. In the direct parallel mode, the attenuator is controlled by the parallel control inputs directly. The LE must be at logic high to control the attenuator in this mode.

### Latched Parallel Mode

In the latched parallel mode, the parallel control inputs will be buffered by registers, and loaded to the outputs when LE is high. The outputs shall not change states when LE is low.

### Power-up States

The power-up (PUP) states will work in both serial and parallel modes, and initiate the attenuator according to the PUP truth table. During power up, the digital inputs shall be held constant for at least 1 µs after $V_{CC}$ reaches 90% of final value. For serial mode, the PUP states will only work when LE is held low. The PUP state shall be locked out after the first LE pulse.

## Functionality
### Modes of Operation: Serial, Direct Parallel, and Latched Parallel

### PUP Truth Table

| Inputs | | | | Gain Relative to Max. Gain | Notes |
|---|---|---|---|---|---|
| PS | LE | PUP2 | PUP1 | | |
| 0 | 0 | 0 | 0 | -31.5 dB | Parallel Mode |
| 0 | 0 | 0 | 1 | -24 dB | |
| 0 | 0 | 1 | 0 | -16 dB | |
| 0 | 0 | 1 | 1 | Insertion Loss | |
| 0 | 1 | X | X | 0 to –31.5 dB (Set VC0.5 - VC16) | |
| 1 | 0 | X | X | 0 to –31.5 dB (Set VC0.5 - VC16) | Serial  Mode |
| 1 | 1 | X | X | No Definition | |

### Serial Interface Timing Characteristics

| Symbol | Parameter | Typical Performance | | | Units |
|---|---|---|---|---|---|
| | | -40°C | 25°C | +85°C | |
| $t_{SCK}$ | Min. Serial Clock Period | 100 | 100 | 100 | ns |
| $t_{CS}$ | Min. Control Set-up Time | 20 | 20 | 20 | ns |
| $t_{CH}$ | Min. Control Hold Time | 20 | 20 | 20 | ns |
| $t_{LS}$ | Min. LE Set-up Time | 10 | 10 | 10 | ns |
| $t_{LEW}$ | Min. LE Pulse Width | 10 | 10 | 10 | ns |
| $t_{LH}$ | Min. Serial Clock Hold Time from LE | 10 | 10 | 10 | ns |
| $t_{LES}$ | Min. LE Pulse Spacing | 630 | 630 | 630 | ns |

• **North America** Tel: 800.366.2266   • **Europe** Tel: +353.21.244.6400
• **India** Tel: +91.80.43537383   • **China** Tel: +86.21.2407.1588
Visit www.macomtech.com for additional data sheets and product information.

*M/A-COM Technology Solutions Inc. and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice.*

## Functionality
### Modes of Operation: Serial, Direct Parallel, and Latched Parallel

### Serial Input Interface Timing Diagram



### Parallel Control Word



30ns Minimum

• **North America** Tel: 800.366.2266   • **Europe** Tel: +353.21.244.6400
• **India** Tel: +91.80.43537383   • **China** Tel: +86.21.2407.1588
Visit www.macomtech.com for additional data sheets and product information.